ALASKA DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF SPILL PREVENTION AND RESPONSE
CONTAMINATED SITES REMEDIATION PROGRAM

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PREDICTING THE OPTIMUM TIME TO SHUT OFF A SOIL VAPOR EXTRACTION SYSTEM

INTRODUCTION

In recent years soil vapor extraction (SVE) has become an accepted method for VOC removal from contaminated unsaturated soils. Others have shown with field and laboratory tests that the mass removal rate of VOCs by SVE systems slows significantly with increasing operation time. This decrease in removal rates usually results in inefficient removal of the remaining mass of VOC in later stages of operation (Figure 1). Since the inception of SVE as a viable contaminated soil restoration strategy, operators of these systems have struggled with determining the best date to terminate operation of their systems. The challenge to these operators is to justify the expense for continued operation of SVE systems that have low mass removal rates but have not removed sufficient amounts of VOCs from the contaminated soil to satisfy a regulatory cleanup standard.

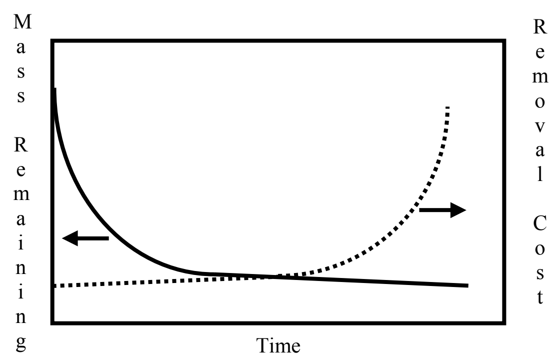

Figure 1 – Relationship between fraction of VOC remaining in the soil with time and removal cost ($/mass) with respect to time for a typical operating SVE system

METHOD

Using principles of soil-gas flow and mass transport through unsaturated soils, stochastic hydrogeology, and uncertainty analysis, we have developed a procedure that can be used to determine the appropriate time to shut off operating SVE systems.

RESULTS AND DISCUSSION

Others have shown that in the later stages of SVE operation, mass removal from the contaminated soil is predominantly controlled by diffusion from areas with relatively low permeability to areas of relatively high permeability. The mass removal curve at late time in Figure 1 hypothetically illustrates the result of diffusion limited transport in VOC contaminated soils treated with SVE. At the point that the system is diffusion limited a simple analysis can be made using the following equation derived by Barnes (2002).

$$\frac{Cf_T}{A} \leq i^{-1}$$

In the above equation, Cf_T is the cost of replacing the existing SVE system that has become diffusion limited with a different technology such as an ex situ biological degradation process, A is the annual cost of operating the current SVE system and i is the interest rate. If the ratio of the replacement cost to the annual operating cost for an operating SVE system is less than or equal to the inverse of the interest rate the system should be shut down and the soil tested. If the SVE system has not reduced the mass of volatile contaminants down to the regulatory limits, then the alternative system should be installed to complete the treatment.

CONCLUSION

The procedure for making the decision on continued operation of an operating SVE system can be summarized as follows:

- Determine an appropriate Cf_T.
- Collect SVE off-gas samples over time and measure VOC concentration.
- With each new sample result, determine the rate of change in VOC concentration for the interval between sampling (change in off-gas VOC concentration over sample time interval).
- If the rate of change for several sample periods tends towards zero, then compare Cf_T/A to i^{-1}.
- Shut the system off if $Cf_T/A \leq i^{-1}$.
- Sample soil to determine if the cleanup standard has been met.

REFERENCE

Barnes, D.L. 2002. Estimation of Operation Time for Soil Vapor Extraction Systems. Accepted for publication in *Journal of Environmental Engineering*.

AUTHORS

David L. Barnes, Ph.D., P.E., Assistant Professor,
Trevor C. White, Research Assistant
Department of Civil & Environmental Engineering, Water Environment Research Center, University of Alaska Fairbanks. 907-474-6126, ffdlb@uaf.edu.
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